

QUALITY CONTROL/QUALITY ASSURANCE, QC/QA, SUPERSTRUCTURE CONCRETE

The Standard Specifications are revised as follows:

SECTION 730, BEGIN LINE 1, INSERT AS FOLLOWS:

**SECTION 730 -- QUALITY CONTROL/QUALITY ASSURANCE, QC/QA,  
SUPERSTRUCTURE CONCRETE**

**730.01 Description.** *This work shall consist of furnishing and placing portland cement concrete for bridge superstructures in accordance with 105.03. This concrete is applicable for use in contracts for bridge rehabilitation, bridge replacement, or bridge construction where an entirely new bridge deck is constructed.*

10 **730.02 Quality Control.** *Quality control of the concrete during production, placement, finishing, and curing shall be the responsibility of the Contractor. The mixture shall be produced by an approved plant in accordance with ITM 405, transported, and placed according to a Quality Control Plan, QCP, prepared and submitted by the Contractor in accordance with ITM 803. The QCP shall be submitted to the Engineer at least 15 days prior to commencing concrete operations.*

20 *Concrete operations shall not begin before the QCP has been accepted and successful trial batch demonstration completed. Concrete mix designs and trial batch demonstrations may be submitted for approval prior to completion of the QCP submittal. A certified concrete technician shall supervise all sampling and testing for process control as defined by the QCP. A certified concrete technician is a Contractor, producer, or consultant employee who has been certified by the Department.*

**MATERIALS**

**730.03 Materials.** *Materials shall be in accordance with the following:*

|    |  |                  |
|----|--|------------------|
|    | <i>Admixtures.....</i>                                       | <i>912.03</i>    |
|    | <i>Castings .....</i>  | <i>910.05</i>    |
|    | <i>Cast Iron Soil Pipe .....</i>                             | <i>908.10</i>    |
| 30 | <i>Coarse Aggregate, Class A or Higher, Size No. 8*.....</i> | <i>904</i>       |
|    | <i>Curing Materials.....</i>                                 | <i>912.01</i>    |
|    | <i>Fabric For Waterproofing.....</i>                         | <i>913.16</i>    |
|    | <i>Fine Aggregate, Size No. 23*.....</i>                     | <i>904</i>       |
|    | <i>Fly Ash.....</i>  | <i>901.02</i>    |
|    | <i>Ground Granulated Blast Furnace Slag .....</i>            | <i>901.03</i>    |
|    | <i>Permanent Metal Forms .....</i>                           | <i>910.03</i>    |
|    | <i>Portland Cement .....</i>                                 | <i>901.01</i>    |
|    | <i>Reinforcing Steel, Epoxy Coated .....</i>                 | <i>910.01</i>    |
|    | <i>Steel Drain Pipe.....</i>                                 | <i>910.07</i>    |
| 40 | <i>Silica Fume .....</i>                                     | <i>901.04</i>    |
|    | <i>Utility Asphalt, UA-1.....</i>                            | <i>902.01(d)</i> |

Water ..... 913.01

\* Or gradation as identified in the QCP

If the contract requires stay-in-place metal forms for the superstructure or if the Contractor elects to use such forms, the coarse aggregate shall be Class AP. Shipping and storage of cement shall be in accordance with 702.04.

50 **730.04 Concrete Mix Design.** A concrete mix design, CMD, shall be in accordance with 730.05 and shall be verified by a trial batch in accordance with 730.06. The CMD shall be submitted in a format acceptable to the Engineer and include the following:

- (a) a list of all ingredients
- (b) the source of all materials
- (c) the gradation of the aggregates
- (d) the absorption of the aggregates
- (e) the SSD bulk specific gravity of the aggregates
- (f) the specific gravity of pozzolan
- 60 (g) the batch mass (weights)
- (h) the names of all admixtures
- (i) the range of admixture dosage rates as recommended by the manufacturer
- (j) the linear equation of unit mass (weight) vs. air content ( $UW = m(\text{Air}) + b$ )

A change to a source of material except for cement, pozzolan, or fine aggregate requires a new CMD.

A CMD in accordance with 730.05 may be substituted for Concrete, Class A, Class B, or Class C in accordance with 702.

70 **730.05 Concrete Mix Criteria.** The CMD not including silica fume, shall produce workable concrete mixtures having the following properties:

|                            |                     |
|----------------------------|---------------------|
| <u>Concrete Properties</u> | <u>Requirements</u> |
|----------------------------|---------------------|

|   |  |
|---|--|
| Minimum portland cement content .....         | 310 kg/ m <sup>3</sup> (520 lbs/ yd <sup>3</sup> ) |
| (when cement or cement and fly ash is used)   |  |
| Minimum portland cement content .....         | 275 kg/ m <sup>3</sup> (460 lbs/ yd <sup>3</sup> ) |
| (when cement and GGBFS is used)               |  |
| Minimum portland cement/fly ash ratio .....   | 3.2 by mass (weight)                               |
| Minimum portland cement/GGBFS ratio .....     | 2.3 by mass (weight)                               |
| Maximum water/cementitious ratio .....        | 0.420  |
| Target air content .....                      | 6.5%   |
| Minimum compressive strength at 28 days ..... | 35 MPa (5000 psi)                                  |
| Slump with HRWR <sup>(1)(2)</sup> .....       | 100 mm (4 in.) to 190 mm (7.5 in.)                 |

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(1) A type F or G admixture to be combined with an air entraining admixture, AEA, a HRWR Admixture System or a HRWRR Admixture System shall be selected from the Department's list of approved PCC Admixtures and Admixture Systems.

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(2) For a superelevated section the slump shall be 50 mm (2 in.) to 110 mm (4.25 in.) unless QCP provisions are implemented to assure that the finished surface will be reasonably true to the planned profiles and cross section utilizing a higher slump concrete.

QC/QA superstructure concrete containing silica fume may be used in lieu of surface sealing the bridge deck and shall be proportioned in accordance with 702.05 and the following.

- 100 (a) The minimum portland cement content shall be 315 kg/ m<sup>3</sup> (530 lb/ yd<sup>3</sup>) with a tolerance not to exceed 1.0% in accordance with 702.06.
- (b) The minimum and maximum cementitious content with silica fume shall be 385-425 kg/m<sup>3</sup> (650-715 lbs/ yd<sup>3</sup>)
- (c) Silica fume shall constitute 7.0%-7.5% of the total cementitious content in the mix design.
- 110 (d) Class F or C fly ash may be used as part of the total cementitious content. The maximum portland cement/fly ash ratio shall be 6.4 by mass (weight).
- (e) The water-cementitious ratio shall be no less than 0.370 and shall not exceed the maximum of 0.420.
- (f) The minimum compressive strength at 28 days shall be 40 MPa (5800 psi).

120 The Contractor may elect to use fine and coarse aggregate gradations in accordance with 904 or may propose the use of alternate gradations. If alternate gradations are proposed, the tolerances shall be as stated in the QCP. In either case, 100% of the coarse aggregate shall pass the 25 mm (1.0 in.) sieve. The combined amount of fine and coarse aggregates passing the 75 μm (No. 200) sieve shall be from 0.0 to 2.0% for sand and gravel, and from 0.0 to 2.5% for sand and crushed stone, or crushed slag.

Proportions will be based upon SSD saturated surface dry aggregates. The fine aggregate shall be at least 35% but not more than 50% of the total volume of the aggregate in each cubic meter (cubic yard).

130 Absorption and bulk specific gravity tests shall be performed on the fine aggregate in accordance with AASHTO T 84 and on the coarse aggregate in accordance with AASHTO T 85, by procedures 8.1 and 8.2. When the SSD bulk specific gravity or absorption test result differs from the Department's most recent value for the source by more than the multi-laboratory precision defined within the appropriate test method, the discrepancy will be investigated. Values

agreed upon by the Contractor and Engineer shall apply when calculating target batch mass (weights) and determining water/cementitious ratio.

140 All cement/pozzolan products, which are portland pozzolan cement type IP or type IS, fly ash without the addition of silica fume, or GGBFS used as an additive, may only be incorporated into the concrete placed between April 1 and October 15 of the same calendar year. These dates will not apply when cement/pozzolan products are used and traffic is not anticipated on the concrete, or if silica fume is used as a portion of the total cementitious material. If portland pozzolan cement type IP is to be used, the minimum portland cement content shall be increased to 360 kg/ m<sup>3</sup> (600 lb/ yd<sup>3</sup>). The use of fly ash as an additive will not be permitted in conjunction with the use of IP or IS blended cements, or GGBFS. Air-entraining cements will not be permitted.

150 QC/QA superstructure concrete shall contain an air entraining agent and either a water reducing, high range, admixture (type F) or a water-reducing, high range, and retarding admixture (type G) as identified in the Department's list of approved PCC Admixture and Admixture Systems. The type admixture used shall not be changed during any individual contiguous pour. The type admixture to be used shall be selected based on the expected concrete temperature, ambient temperature, initial set time, lineal rate of deck placement in m/h (ft/h), and dead load deflection of any structural members containing the concrete. When either temperature is expected to be 18°C (65°F) or above and dead load deflection is of concern; type G admixture, or HRWRR admixture system shall be used. If a fly ash or GGBFS pozzolan is used in the concrete, the dosage of type D or type G may be lowered to an amount as recommended in writing by the manufacturer of the admixture. A type F admixture or HRWR admixture system shall be used when both temperatures are expected to be below 18°C (65°F) or dead load deflection is not of concern. Retardation may be required due to the structure design or the  
160 proposed pour sequence in accordance with 704.04. A higher temperature restriction regulating the need to retard the concrete initial set time may be requested in writing and shall substantiate the effects of concrete initial set time, lineal rate of deck placement, and dead load deflection.

The admixture addition rate shall not be reduced below the minimum, or exceed the maximum rate recommended by the manufacturer, regardless of the temperature of the concrete or ambient temperature.

170 The CMD by absolute volume method shall be submitted to the Engineer for verification at least seven days prior to the trial batch demonstration. An explanation of intended use for each mix design shall be provided.

**730.06 Trial Batch.** A trial batch shall be produced and tested by the Contractor's certified technician and the Engineer's qualified technician to verify that the CMD meets the concrete mix criteria. Sufficient concrete shall be batched to accurately represent the CMD and provide an amount of concrete to perform all tests from the same batch. The concrete shall be batched and mixed in accordance with 702.06 and 702.07. The Engineer will test the trial batch and provide the Contractor with the results. Trial batch concrete shall not be used for more than one test, except the concrete used for the unit mass (weight) may be used to conduct the

180 *air content test. The concrete shall be agitated at least 15 min before testing and not exceeding 45 min.*

190 *The Contractor's test results will be used to validate CMD compliance with the required concrete properties. The air content for the trial batch concrete shall measure a minimum of 5.0%. An additional pair of cylinders shall be cast for determination of average compressive strength at an age of seven days. These cylinders are for information only. Compressive strength results by the Contractor which achieve the minimum requirements at an earlier age will be considered as validating that concrete property of the CMD; however, strengths at 28 day are still required. All molds, facilities, and materials necessary to prepare and initially cure cylinders shall be provided. Gradations shall be determined to validate the fine and coarse aggregates used.*

190 *The Engineer's qualified technician will measure the concrete properties and verify compliance to the Contractor's results within the following tolerances*

|                                    |   |
|------------------------------------|---|
| <i>Aggregate Correction Factor</i> | <i>±0.1% Pt.</i>                                      |
| <i>Air Content</i>                 | <i>±0.5% Pt.</i>                                      |
| <i>Unit Mass (Weight)</i>          | <i>±30 kg/ m<sup>3</sup> (1.9 lb/ ft<sup>3</sup>)</i> |
| <i>Slump</i>                       | <i>±25 mm (1.0 in.)</i>                               |
| <i>28 day Compressive Strength</i> | <i>±8.5%</i>  |
| <i>Water/Cementitious Ratio</i>    | <i>±0.015</i>   |

200 *Unit mass (weight) is not to exceed a tolerance of ± 0.5% of the CMD's predicted value at the air content measured.*

*All test results not within tolerance are to be investigated by the Contractor and Engineer as to the cause and determine corrective actions needed to resolve the discrepancy.*

210 *The CMD batch mass (weights) may be adjusted by the amount of over, or under yielding. The aggregates may need a re-test for SSD bulk specific gravities and absorption as part of the investigation. The final CMD shall be established for the concrete after all discrepancies are resolved. Following the trial batch demonstration all required test results, final CMD, and the linear equation shall be submitted to the Engineer for approval.*

*CMD's, which have had a successful trial batch demonstration on another contract specifying QC/QA superstructure concrete, may be submitted for the Engineer's approval. The tolerance of testing concrete properties, as measured by the Department's qualified technician and the Contractor's certified concrete technician, may be verified on current class C concrete production.*

220 *Except for adjustments to compensate for routine aggregate moisture fluctuations, changes in target aggregate (SSD) batch mass (weights) shall be documented and submitted to the Engineer for approval, prior to implementing. A maximum adjustment of ±3 percentage points of fine to total aggregate ratio by volume will be permitted. Changes to the dosage amounts of admixtures will be permitted. A new CMD shall be prepared and successfully demonstrated for changes in*

the source of a material (except for cement, pozzolan, or fine aggregate), the amounts of cementitious materials, increase in water/cementitious ratio, adjustments of greater than  $\pm 3$  percentage points of fine to total aggregate ratio, or the addition or deletion of admixtures.

230 **730.07 Lots and Sublots.** Sampling and testing of the concrete properties will be performed on random cubic meter (cubic yard) of QC/QA superstructure concrete within each subplot. Lots will be defined as 120.0 m<sup>3</sup> (150.0 yd<sup>3</sup>) for each mix design as measured against the plan quantity. Lots will be further subdivided into three sublots of 40.0 m<sup>3</sup> (50.0 yd<sup>3</sup>) each within a lot. Partial sublots of 12.0 m<sup>3</sup> (15.0 yd<sup>3</sup>) or less will be added to the previous subplot. Partial sublots greater than 12.0 m<sup>3</sup> (15.0 yd<sup>3</sup>) will constitute a full subplot. Partial lots of two sublots constitute a full lot. If there is only one subplot in an incomplete lot then the partial subplot will be included in the previous lot.

**730.08 Test Methods and Procedures.** The following test methods and procedures apply with exceptions as listed below.

|     |   |                        |
|-----|---|------------------------|
| 240 | Air Test .....                                  | AASHTO T 152 or T 196* |
|     | Compressive Strength .....                      | AASHTO T 22            |
|     | Flexural Strength .....                         | AASHTO T 97            |
|     | High Pressure Air Content of Hardened PCC ..... | ITM 401                |
|     | Making and Curing Specimens .....               | AASHTO T 23            |
|     | Moisture Content, Aggregate .....               | AASHTO T 255           |
|     | Obtaining and Testing of Drilled Cores .....    | AASHTO T 24            |
|     | Sampling Fresh Concrete .....                   | AASHTO T 141           |
|     | Sampling Stockpiled Aggregates .....            | ITM 207                |
| 250 | Sieve Analysis of Aggregates .....              | AASHTO T 27            |
|     | Slump .....                                     | AASHTO T 119           |
|     | Specific Gravity and                            |                        |
|     | Absorption, Coarse Aggregate. ....              | AASHTO T 85**          |
|     | Specific Gravity and                            |                        |
|     | Absorption, Fine Aggregate. ....                | AASHTO T 84            |
|     | Resistance to Chloride Ion Penetration .....    | AASHTO T 277           |
|     | Unit Mass (Weight) .....                        | AASHTO T 121           |
|     | Water-Cementitious Ratio .....                  | ITM 403                |

260 \* If slag aggregate is used, the method and procedure for the test shall be in accordance with AASHTO T 196.

\*\* Sections 8.1 and 8.2

**(a) Exceptions to AASHTO T 23.** The exceptions to AASHTO T 23 for making and curing specimens in the field shall be as follows.

1. Initial curing of cylinders shall be no less than 16 h or more than 48 h.
2. Non-watertight beam forms (molds) will be permitted.

- 270
3. *After 24 h, the molded beam specimens shall be taken to the storage location and removed from the molds.*
  4. *Field stored beams will not require  $24 \pm 4$  h immersion in water saturated with calcium hydroxide prior to the time of testing.*

*(b) Exceptions to AASHTO T 27. The exceptions to AASHTO T 27 for conducting a sieve analysis are in accordance with 904.06.*

280 *(c) Exception to AASHTO T 84. The exceptions to AASHTO T 84 for determining SSD specific gravity and absorption for the fine aggregate shall be as follows:*

1. *The SSD bulk specific gravity shall be reported to the nearest 0.001 and the absorption reported to the nearest 0.01 %.*

*(d) Exception to AASHTO T 85. The exceptions to AASHTO T 85 for determining SSD specific gravity and absorption for the coarse aggregate shall be as follows:*

- 290
1. *The 15 h soak period shall not be eliminated.*
  2. *The in-water mass (weight) shall be determined following the 15 h soaking period prior to determining the SSD mass (weight).*
  3. *The SSD bulk specific gravity shall be reported to the nearest 0.001 and the absorption reported to the nearest 0.01 %.*

*(e) Exceptions to AASHTO T 97. The exceptions to AASHTO T 97 for conducting a flexural test shall be as follows:*

- 300
1. *The beam size shall be measured to the nearest 1.0 mm (1/16 in.).*
  2. *The test result shall be discarded when the break occurs outside the middle third of the beam.*

*(f) Exceptions to AASHTO T 121. The exceptions to AASHTO T 121 for determining the unit mass (weight) of concrete shall be as follows:*

1. *Mass (weight) shall be determined to the nearest 0.005 kg (0.01 lb).*

310 *(g) Exceptions to AASHTO T 141. The exceptions to AASHTO T 141 for sampling fresh concrete in the field shall be as follows:*

1. *The entire sample may be obtained from one portion of the load after at least  $0.25 \text{ m}^3$  ( $0.25 \text{ yd}^3$ ) of concrete has been discharged.*

*(h) Exceptions to AASHTO T 152. The exceptions to AASHTO T 152 for determining the air content in PCC shall be as follows:*

- 320 1. *The aggregate correction factor shall be determined in accordance with 6.4.3 except that the volume of water shall not be removed from the assembled and filled apparatus.*
- 2. *The aggregate correction factor test shall be re-run for confirmation if the test results for gravel is greater than 0.4% or if the test results for crushed stone is greater than 0.6%.*

330 **730.09 Testing Facilities and Equipment.** *An easily accessible means of obtaining concrete samples at the point of placement and transporting the samples from the bridge deck for testing shall be provided. All molds, facilities, and materials necessary to prepare and initially cure quality control and acceptance cylinders shall be provided at the work site.*

**CONSTRUCTION**

**730.10 General.** *Construction operations as applicable shall be in accordance with 702, 703 and 704.*

340 **730.11 Removal and Re-use of Forms.** *The forms for any portion of the structure shall not be removed until concrete is strong enough to withstand damage. Field operations shall be controlled by the Contractor using the cure period or beam testing in accordance with the requirements of 702.13(g) and 702.13(h), respectively. If cylinders are used to control form removal, the average of all cylinders tested at the age specified shall meet or exceed the required compressive strengths. The number of cylinders to be tested and the requirement of any individual cylinder shall be in accordance with 730.13.*

| <u>Concrete Used In</u>                             | <u>Required<br/>Compressive<br/>Strength, MPa (psi)<br/>Dead Load Only</u> |
|---|--|
| 350 <i>Girders, Arches, and Similar units .....</i> | <i>17.25 (2500)</i>  |
| <i>Interior Bent or Pier Caps.....</i>              | <i>22.75 (3300)</i>  |

*The cylinders shall be field cured in accordance with AASHTO T 23, under the same conditions as the concrete they represent.*

**730.12 Falsework and Centering.** *Falsework and arch centering for structural elements shall be in accordance with 702.14.*

360 **730.13 Application of Loads.** *The application of loads to new concrete shall be determined by cure period or test beam requirements of 702.24. The Contractor may utilize compressive strength of standard specimens to control application of loads to new concrete. The*

*compressive strength shall be the average of the strengths of all cylinders tested at the age specified, with a minimum of two cylinders. If the compressive strength of one or more cylinders in one strength test is below 75% of the required strength, the entire test will be considered as not meeting the required strength. Test cylinders designated for this purpose shall be prepared in accordance with AASHTO T 23, and field cured by the Contractor under the same conditions as the concrete they represent. The application of loads to new concrete shall be in accordance with the following:*

370 (a) *Light materials and equipment may be carried on bridge decks only after the concrete has been in place at least 24 h, provided curing is not interfered with and the surface texture is not damaged. Vehicles, material, and equipment needed for construction activities, having a gross mass (weight) between 450 and 1800 kg (1000 and 4000 lbs) will be allowed on any span only after the last placed concrete has attained a minimum compressive strength of 17.25 MPa (2500 psi). Loads in excess of above will not be permitted on structures until all concrete required to carry live loads has been cured for at least 15 days or until a compressive strength of 27.50 MPa (4000 psi) has been attained. For concrete poured when the average temperature is less than 10°C (50°F), the cure periods shall be increased 4 days.*

380 (b) *Unbalanced backfill will not be permitted until the concrete required to resist it is at least 10 days old or a compressive strength of 20.00 MPa (2900 psi) has been attained. The unbalanced height shall not exceed 3 m (10 ft) until the concrete is at least 15 days old or a compressive strength of 22.75 MPa (3300 psi) has been attained. For concrete poured when the average temperature is less than 10°C (50°F), the cure periods shall be increased 4 days.*

390 *If, at the expiration of the specified periods, test cylinders do not indicate the required compressive strength, the periods shall be lengthened until the required strength is attained. If portland-pozzolan cement, type IP, or fly ash or GGBFS used as an additive is incorporated into the concrete, the specified periods shall not apply and the application of loads shall be controlled by cylinder tests. No contract time extension will be considered for delays due to additional time necessary to attain specified strengths.*

400 *Traffic, live loads, and backfill against wingwalls, spandrel walls, and abutments may be allowed when test cylinders indicate a compressive strength of 22.75 MPa (3300 psi). Before traffic is permitted over a concrete structure built to be under fill, it shall be covered with a minimum of 225 mm (9 in.) of earth or other suitable material. All other structures shall be properly protected against impact or other damage.*

**730.14 Substandard Work.** *General problems and procedures, which cause an obviously substandard product, shall be promptly corrected. The Engineer and Contractor will jointly review the operations to ensure compliance with the QCP. Continuous violations of compliance with the QCP will result in suspension of operations.*

The option to remove and replace the completed superstructure, or to leave it in place will be as directed. Material in this category will be adjudicated as a failed material in accordance with 105.03.

410 **730.15 Finishing.** The concrete shall be finished in accordance with 702.21 and 704.05.

**730.16 Wet Curing.** After finishing and texturing in accordance with 704.05, the concrete shall be cured in accordance with 704.06 and 702.22, except as modified herein.

420 An evaporation retardant shall be applied, in accordance with the manufacturer's recommendation, to the exposed concrete surface immediately after finishing or texturing operations. Reapplication of the retardant shall be performed whenever the surface is disturbed, or when drying of the surface is observed. The evaporation retardant shall be one of the products listed below. A type D certification for the evaporative retardant shall be in accordance with 916 and submitted to the Engineer prior to use

1. Confilm, manufactured by Master Builders Technologies; 3715 Bargetown Road, Room 214; Louisville, KY 40218
2. Sika-Film, manufactured by Sika Corporation; 2930 Switzer Road; Columbus, OH 43219
3. Eucobar, Euclid Chemical Company; 19218 Redwood Road; Cleveland, OH 44110

430 Application of evaporative retardant may be eliminated for concrete that does not contain silica fume, if the Contractor can substantiate the evaporation rate as not exceeding 0.75 kg/m<sup>2</sup>/h (0.15 lbs/ft<sup>2</sup>/h). Evaporative retardant shall be applied to the finished or textured surface of concrete containing silica fume, regardless of the evaporation rate. If the evaporation rate exceeds 0.50 kg/m<sup>2</sup>/h (0.10 lbs/ft<sup>2</sup>/h) during placement of concrete containing silica fume, fog misting, as recommended by the silica fume manufacturer, shall be initiated prior to the texturing operation. Fog misting shall not be excessive to cause water to wash the fresh concrete surface, or to stand on the surface during floating or troweling operations.

440 The rate of water evaporation shall be determined during concrete placement in accordance with ACI 308, Section 1.2.1. or the following metric (English) equation:

$$E = 5[(T_c + 18)^{2.5} - r(T_a + 18)^{2.5}][V + 4] \times 10^6$$

$$(E = [T_c^{2.5} - (r \times T_a^{2.5})][1 + 0.4V] \times 10^6)$$

where:

$E$  = Evaporation rate, kg/m<sup>2</sup>/h (lb/ft<sup>2</sup>/h)

$T_c$  = Concrete temperature, °C (°F)

450  $T_a$  = Ambient temperature, °C (°F)

$$r = (RH \%)/100$$

$V =$  Wind velocity, k/h (mi/h)

Measurements of  $T_a$ ,  $r$ , &  $V$  shall be obtained on-site and compared for accuracy with readings from the nearest weather station monitored by the National Climatic Data Center. Measurement of  $T_c$  shall be determined from the concrete placed.

460 Concrete in bridge decks or the top surface of reinforced concrete slab bridges shall be wet cured continuously for at least 168 h commencing immediately after the surface is able to support the protective covering without deformation. An extended wet cure period is not required for concrete containing pozzolans.

Membrane forming curing compound shall not be applied to concrete in bridge decks or the top surface of reinforced concrete slab bridges.

470 Surfaces to be cured shall be protected by covering with cotton mats, burlap, or other satisfactory protective material that is kept continuously and thoroughly wet during the curing period. The protective covering shall be suitably anchored. Curbs, walls, handrails, copings, and other surfaces requiring a finish in accordance with 702.21 may have the covering temporarily removed for finishing, but the cover shall be restored as soon as possible.

**730.17 Sealing.** The concrete surface shall be prepared and sealed in accordance with 709, except if the concrete contains silica fume. The concrete containing silica fume shall not be sealed.

480 **730.18 Acceptance Testing and Approval.** The Engineer will randomly select the quantity for sampling sublots of concrete in accordance with ITM 802. The air content, plastic unit mass (weight), and compressive strength tests will be determined for each subplot sample during concrete production. Sublot samples of concrete will be obtained at the work site at the point of placement. When calculations are performed, rounding will be in accordance with 109.01(a). Sublot acceptance test results will be shared with the Contractor in a timely manner.

(a) **Slump Test.** For any load of concrete, the slump may be visually estimated. If it is suspected that the slump is not within the allowable limits at the point of placement, the Contractor's certified concrete technician will be informed. The truck in question shall discontinue placement until a slump test is conducted to verify compliance. If the slump is outside compliance, the technician shall test for air content and unit mass (weight). The truck shall not resume discharge in the structure until quality control test results substantiate compliance.

490 (b) **Air Content and Unit Mass (Weight) Tests.** The air content and unit mass (weight) will be measured once in each subplot sample.

A line parallel to the CMD Linear Equation will be established which represents an increase in water/cementitious ratio to a value of 0.420. An individual subplot having a unit mass (weight), for the air content measured, at or below the value representing the maximum allowable water/cementitious ratio, will have two additional cylinders cast. A test specimen will be extracted

from each cylinder and tested by the Department in accordance with AASHTO T 277 at an age of 56 days. The value will be the average of the two specimens. A value greater than 4000 coulombs will be adjudicated as a failed material in accordance with 105.03.

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Calculations for air content percentage will be made and reported to the nearest figure in the first decimal place. Calculations for unit mass (weight) will be made and reported to the nearest 1 kg/ m<sup>3</sup> (0.1 lb/ ft<sup>3</sup>). Calculations for resistance to chloride ion penetration will be made and reported to the nearest 10 coulombs.

**(c) Compressive Strength Test.** Two cylinders will be cast from each subplot sample. Initial curing of cylinders shall be completed by submerging the specimens in water saturated with calcium hydroxide at a temperature range between 16 to 27°C (60 to 80°F) for no less than 16 h or more than 48 h. Each cylinder will be tested for 28 day compressive strength and the values averaged to determine the 28 day subplot compressive strength

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Calculations for subplot compressive strength will be made to the nearest figure in the second decimal place for MPa units (whole psi unit).

**730.19 Pay Factors.** Quality Assurance Adjustment for each lot will be determined based on pay factors for concrete properties of air content, range of air content, and compressive strength. The formula for calculating the adjustment is as follows:

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$$q_i = L_i \times U_m (PF_{ai} + PF_{ri} + PF_{ci} - 3.00)$$

where:

$q_i$  = quality assurance adjustment for individual( $i^{th}$ ) lot

$L_i$  = quantity for  $i^{th}$  lot

$U_m$  = unit price for material, \$125/ m<sup>3</sup> (\$96/ yd<sup>3</sup>)

$PF_{ai}$  = pay factor for air content in  $i^{th}$  lot

$PF_{ri}$  = pay factor for air content range in  $i^{th}$  lot

$PF_{ci}$  = pay factor for compressive strength in  $i^{th}$  lot

530

The total quality assurance adjustment will be calculated as follows:

$$Q = \sum q_i$$

For lots  $i=1$  to  $n$

where:

$Q$  = total quality assurance adjustment

$i$  = individual lot

$n$  = last lot

540

The pay factors for lot air content, air content range for lot, and lot compressive strength values will be determined as tabulated below:

- a) **Air Content.** The air content values for each lot will be the average of the respective test values of the sublots within the lot. Air content range will be determined as the difference between the highest subplot air content and the lowest subplot air content within the lot. A pay factor will be assessed on lot values for average air content and range of individual air content values within a lot as follows:

550

1. Lots

| <i>Lot Air Content</i>                         |   |                                   |
|--|---|-----------------------------------|
| <i>Concrete without Silica Fume Percent, %</i> | <i>Concrete with Silica Fume Percent, %</i> | <i>Pay Factor PF<sub>ai</sub></i> |
| 10.0 or Greater                                | 10.0 or Greater                             | *                                 |
| 9.9  | 9.9   | 0.00                              |
| 9.7 – 9.8                                      | 9.7 – 9.8                                   | 0.25                              |
| 9.5 – 9.6                                      | 9.5 – 9.6                                   | 0.55                              |
| 9.3 – 9.4                                      | 9.3 – 9.4                                   | 0.80                              |
| 9.0 – 9.2                                      | 9.0 – 9.2                                   | 0.90                              |
| 5.7 – 8.9                                      | 5.3 – 8.9                                   | 1.00                              |
| 5.0 – 5.6                                      | 4.8 – 5.2                                   | 0.95                              |
| 4.7 – 4.9                                      | 4.5 – 4.7                                   | 0.90                              |
| 4.6  | 4.4   | 0.40                              |
| 4.5  | 4.3   | 0.00                              |
| 4.4 or less                                    | 4.2 or less                                 | *                                 |

| <i>Air Content Range Within Lot</i> |                                   |
|-------------------------------------|-----------------------------------|
| <i>Percentage Points</i>            | <i>Pay Factor PF<sub>ri</sub></i> |
| 4.1 or Greater                      | 0.94                              |
| 3.6 – 4.0                           | 0.96                              |
| 3.0 – 3.5                           | 0.98                              |
| 0.0 – 2.9                           | 1.00                              |

\* The material will be adjudicated as a failed material in accordance with 105.03. The concrete may be subject to removal and replacement or left in place with reduced or no payment.

2. Sublots. An individual subplot having an air content of less than 4.0% or more than 10.0%, will be adjudicated as a failed material in accordance with 105.03.

560

- b) **Compressive Strength Pay Factors.** The test values for each lot will be the average of the respective test values of the sublots within the lot.

1. Lots.

| <i>28 Day Lot Compressive Strength</i>   |                                       |                                       |
|--|---------------------------------------|---------------------------------------|
| <i>Without Silica Fume<br/>MPa (psi)</i> | <i>With Silica Fume<br/>MPa (psi)</i> | <i>Pay Factor<br/>PF<sub>ci</sub></i> |
| <i>34.47 (5000) or above</i>             | <i>39.99 (5800) or above</i>          | <i>1.00</i>                           |
| <i>34.23 – 34.46 (4964 – 4999)</i>       | <i>39.74 – 39.98 (5764 – 5799)</i>    | <i>0.98</i>                           |
| <i>33.98 – 34.22 (4928 – 4963)</i>       | <i>39.50 – 39.73 (5728 – 5763)</i>    | <i>0.96</i>                           |
| <i>33.73 – 33.97 (4892 – 4927)</i>       | <i>39.25 – 39.49 (5692 – 5727)</i>    | <i>0.94</i>                           |
| <i>33.48 – 33.72 (4856 – 4891)</i>       | <i>39.00 – 39.24 (5656 – 5691)</i>    | <i>0.92</i>                           |
| <i>33.24 – 33.47 (4820 – 4855)</i>       | <i>38.75 – 38.99 (5620 – 5655)</i>    | <i>0.90</i>                           |
| <i>32.99 – 33.23 (4784 – 4819)</i>       | <i>38.50 – 38.74 (5584 – 5619)</i>    | <i>0.84</i>                           |
| <i>32.74 – 32.98 (4748 – 4783)</i>       | <i>38.26 – 38.49 (5548 – 5583)</i>    | <i>0.68</i>                           |
| <i>32.49 – 32.73 (4712 – 4747)</i>       | <i>38.01 – 38.25 (5512 – 5547)</i>    | <i>0.36</i>                           |
| <i>32.24 – 32.48 (4676 – 4711)</i>       | <i>37.76 – 38.00 (5476 – 5511)</i>    | <i>- 0.28</i>                         |
| <i>32.23 (4675) or less</i>              | <i>37.75 (5475) or less</i>           | <i>*</i>                              |

\* The material will be adjudicated as a failed material in accordance with 105.03. The concrete may be subject to removal and replacement or left in place with reduced or no payment.

570 2. Sublots. A subplot test value for concrete with and without silica fume, having a compressive strength value less than 35.75 MPa (5200 psi) and 30.30 MPa (4400 psi), respectively, will be adjudicated as a failed material in accordance 105.03.

580 **730.20 Appeal Procedures.** If the Contractor does not agree with the air content or compressive strength acceptance test results for a subplot, an appeal may be submitted. The Department will be the final authority regarding acceptance and assessing adjustment points for air content and compressive strength test results for the lot. The final adjustment points will be used in assessing any credit to the contract. An appealed subplot resulting in a failed material will be adjudicated in accordance with 105.03. Appeals shall satisfy the following criteria:

- (a) Appeals shall be submitted in writing to the Engineer within five calendar days of receipt of the Engineer's written results for the lot.
  - (b) The submission shall contain applicable quality control test results that equals or exceeds the number of tests required.
  - (c) The difference between the acceptance air content test result and the nearest quality control test result shall be at least 0.5 percentage point.
  - (d) The difference between the acceptance compressive strength test result and the nearest quality control test result shall be at least 0.70 MPa (100 psi).
- 590

*Appeals will be adjudicated by evaluation of cores taken by the Contractor. The diameter of the cores shall be 95 or 100 mm (3.75 or 4.00 in.). Appeal coring shall be completed within 30 days of acceptance of the appeal unless traffic restrictions prevent the coring. All core holes shall be filled with PCC within 24 h of drilling. If the Engineer's cores are subsequently damaged, additional coring within a specific subplot or sublots will be the responsibility of the Department.*

600 *The Engineer will determine the location of the cores that most closely approximates the appropriate subplot acceptance sample location. Cores shall be obtained in accordance with AASHTO T 24 and in the presence of the Engineer. The Engineer will take immediate possession of the cores.*

*The Engineer will identify and mark each core as to its location and submit the cores to the Materials and Tests Division for analysis.*

610 *(a) Air Content. Four cores, 95 or 100 mm (3.75 or 4.00 in.) in diameter, shall be taken for each subplot. The hardened concrete air content will be determined and converted to a value representing air content in the plastic concrete in accordance with ITM 401.*

*The average air content from the four cores will be determined for the subplot in question. This value will be used to determine all subsequent actions involving the subplot as well as the lot to which it is part.*

*(b) Compressive Strength. Four cores, 95 or 100 mm (3.75 or 4.00 in.) in diameter, shall be obtained from each subplot. Each core will be tested for compressive strength in accordance with AASHTO T 24.*

620 *The average core compressive strength will be determined for the subplot in question. This value will be used to determine all subsequent actions involving the subplot as well as the lot to which it is part.*

*730.21 Method of Measurement. QC/QA superstructure concrete will be measured by the cubic meter (cubic yard) in accordance with the neat lines or as directed. However, no allowance will be made for variations in beam fillet depths, coping depths, or diaphragm depths. Reinforcing steel will be measured in accordance with 703.07. Castings and cast iron pipe will be measured in accordance with 702.27.*

630 *730.22 Basis of Payment. The accepted quantities of QC/QA superstructure concrete will be paid for at the contract unit price by the cubic meter (cubic yard) of concrete, complete in place. Reinforcing steel will be paid for in accordance with 703.08. Castings and cast iron pipe will be paid for in accordance with 702.28.*

Adjustments to the contract payment with respect to air content, air content range, and compressive strength for concrete produced will be included in a quality assurance adjustment pay item. The unit price for this pay item will be one dollar (\$1.00) and the quantity will be in units of dollars. The quantity is the total calculated in accordance with 730.19. An extra work order developed in accordance with 109.05 will be prepared to reflect contract adjustments.

640

Payment will be made under:

| <i>Pay Item</i>                            | <i>Metric Pay Unit Symbol<br/>(English Pay Unit Symbol)</i> |
|--|---|
| <i>QC/QA Superstructure Concrete .....</i> | <i>m3 (CYS)</i>   |
| <i>Quality Assurance Adjustment .....</i>  | <i>DOL</i>  |

650

*The cost of preparing a QCP, conducting trial batch demonstrations, performing quality control testing, and similar requirements included herein will not be paid for directly but shall be included in the cost of QC/QA Superstructure Concrete.*

*The cost of coring and refilling of the bridge deck holes for appeals shall be supplied with no additional payment.*

*Traffic control for appeal coring shall be supplied with no additional payment.*